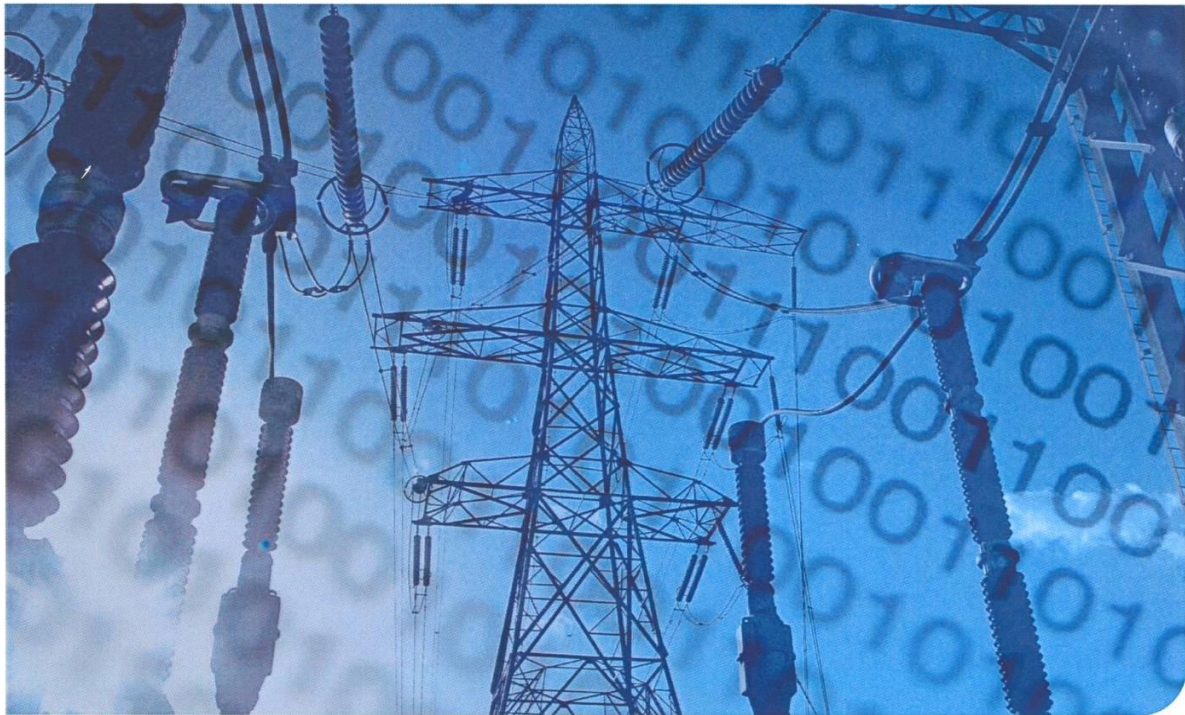


# KPI's for the Electricity Sector in the Kingdom of Saudi Arabia

## Audit Manual



Electricity & Co-generation Regulatory Authority

KEMA International B.V., The Netherlands

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## 1 INTRODUCTION

As part of the KPI Framework developed by ECRA, licensed<sup>1</sup> utilities are required to report on an annual basis the values for the KPI's as specified in the KPI Manual<sup>2</sup>. In order to ensure that the reported values are in line with the specifications, ECRA will perform audits of the underlying processes and data applied by the utility in arriving at the KPI values. This Audit Manual provides guidance to ECRA on how to conduct these audits.

Apart from ECRA, the utilities may also use this Audit Manual for their own internal auditing practices. Doing so can help to improve the data recording processes and prepare for the audits to be conducted by ECRA. The audit performed by ECRA will nevertheless provide the final outcome of whether the reported KPIs are accepted or not.

The following KPIs have been established for the electricity sector in Saudi Arabia (see KPI Manual for details), and which are subject to annual auditing:

<b>Generation</b>		<b>Distribution</b>	
G1	Availability Factor (AF)	D1	SAIDI
G2	Forced Outage Factor (FOF)	D2	SAIFI
G3	Scheduled Outage Factor (SOF)	D3	MAIFI [2011]
G4	Equivalent Forced Outage Rate (EFOR)	D4	Network Losses [2012]
G5	Starting Reliability (SR)		
G6	Gross Capacity Factor (GCF)		
G7	Net Capacity Factor (NCF)		
<b>Transmission</b>		<b>Customer Service</b>	
T1	ENS	C1	Average Time to Supply – Existing Connections [2013]
T2	SAIDI-T	C2	Average Time to Supply – New Connections
T3	SAIFI-T	C3	Average Time to Reconnect After Payment
T4	MAIFI-T	C4	Notification of Interruption of Supply [2012]
T5	Out100 km	C5	Frequency of Complaints
T6	Voltage Dips [2012]	C5	Frequency of Billing Complaints
T7	Network Losses [2012]	C7	Average Time to Resolve Billing Complaints
		C8	Average Waiting Time Call Center

<sup>1</sup> Utilities in Saudi Arabia require a license from ECRA in order to operate in the business of generation, transmission or distribution of electricity, according to the Electricity Law 2005. Article 14 4(a) obliges the Licensee to provide data requested by ECRA

<sup>2</sup> KPI Manual issued by KEMA 22 May 2009 version 1.0

In addition, the following supporting data should also be audited for the generation sector:

Supporting Information	Unit	Level
Service Factor (SF)	%	Per Admin Region and per Technology
Gross Maximum Capacity (GMC)	MW	
Net Maximum Capacity (NMC)	MW	
Gross Actual Generation (GAG)	MWh	
Net Actual Generation (NAG)	MWh	
Gross Annual Heat Rate (GAHR)	BTU/kWh	

## 2 AUDIT OVERVIEW

### 2.1 AUDIT OBJECTIVE

The objective of the audit is to establish whether the KPIs reported by the licensed utility to ECRA are sufficiently accurate in order to be accepted by ECRA. To achieve this, ECRA will perform an audit of the underlying processes in place and the data collected by the utility to compute the reported KPI.

In addition, the annual auditing process is intended to provide independent feedback to companies in order to continually improve their KPI processes. Targets and incentives for KPIs will be set at a later date (after at least the first 2 years of auditing).

### 2.2 AUDIT PLANNING AND TIMELINE

The following schedule provides a suggested timeline for compilation of KPI data by the utilities, reporting to ECRA, and completion of annual audits.

Step	Activity	Who	Deadline
1	Complete data collection of previous year	Utility	31 December
2	Draft KPI's computed	Utility	31 January
3	Internal Audits completed	Utility	15 February
4	Formal submission of KPI's and data computation templates to ECRA	Utility	1 March
5	On site audits	ECRA	1 – 30 April
6	Draft audit reports & revision of KPIs (if required)	ECRA	31 May
7	Publication of final KPI results by ECRA	ECRA	30 June

The audit procedure consists of the following steps:

1. The utility collects the relevant data for computing the KPI's during the course of the year. This data is recorded according to the KPI Manual specifications.

2. During the month of January, the utility computes first draft values of the various KPI's according to the definitions provided in the KPI Manual.
3. The month of February is used for conducting internal audits by the utility staff. The purpose of these internal audits is to ensure that the data collection processes and KPI computations are performed in line with ECRA's specifications. Any deviations from these specifications can be corrected. The internal audit also acts as a preparation for the audit to be conducted by ECRA.
4. The KPI values are finalised and the computation templates are submitted to ECRA by the utility.
5. ECRA notifies the utility of the reception of the KPI information and sets out the schedule for on-site audits, including the following information:
  - The purpose of the audit
  - Introduction of ECRA staff and supporting consultants/auditors
  - The support required from the utility in terms of access to data and availability of personnel for interviews and providing explanations
  - Explanation of the audit process, planning and deadlines
6. Draft audit reports are issued by ECRA to the companies including any adjustments / revision of KPI values, as found during the audits.
7. The KPI results are published by ECRA (the final audit reports are confidential to each company and should take account of comments received).

### 2.3 **AUDIT METHODOLOGY**

The audit process is undertaken for each KPI. Certain KPIs however can be clustered and assessed simultaneously.

The auditing methodology consists of two parts:

- (1) Process Review, and
- (2) Data Audits.

The process review focuses on the KPI data collection process. This has a more qualitative nature and aims to review the robustness of the management processes implemented by the company to collect and report the KPIs.

The data audits on the other hand are of a quantitative nature and here the aim is to verify whether the KPI figures submitted by the company are correct. In this stage the raw data records, calculations and assumptions are checked, as described further in section 4 of this manual.

The audit is concluded with an Audit Report. This report presents the findings of the audits, and the final KPI values. Also included in the final reports are the recommended actions to be completed before the next year's audits

The two audit steps are explained in more detail in the following sections.

## 3 PROCESS REVIEW

### 3.1 APPROACH

The purpose of the Process Review is to obtain insight into the adequacy of the processes set in place by the utility for the purpose of measuring the KPIs. At the same time, the process review also provides the company with an opportunity to explain its KPI data collection and reporting process and highlight any specific issues relevant to the process.

The Process Review is carried out through interviews with company representatives. This includes the KPI contact person and management as well as front-line staff of departments involved in the KPI data collection process.

The information provided during the interview should be verified by the auditor through supporting documentation or through witnessing the systems and software referred to by the company representatives.

During the process review the auditor should also verify whether the company has implemented the action items that were highlighted in the Audit Report from the previous year. Where items have not been followed up or other action points arise, these should be documented in the Audit Report.

The Process review stage of the auditing procedure produces two outcomes:

- Process descriptions
- Process scoring

These are described further below.

### 3.2 PROCESS DESCRIPTIONS

In order to document in a useful manner the observations made by the auditor an overview description of KPI processes should be prepared (to be included in the final audit reports). This should assist in understanding the methods and procedures used by the company to meet the requirements of the KPI system, as well as any deficiencies observed.

The process descriptions should include a step by step explanation of data sources, front-line records (such as log books), customer call records, data bases and software systems. Screen shots and other samples should be provided where this assists in describing the KPI processes. The process descriptions should explain the collection and aggregation of KPI information starting from the front-line raw data, through to the local or regional level and finally to the head office level to calculate overall company KPIs.

An understanding of the KPI processes for each company will normally be attained via meetings or presentations by local or regional managers as well interviews with front-line staff (e.g. shift engineers, plant operators). For each of these meetings the auditor should produce notes containing the following information:

- Date, time, and location of the process review meeting
- Contact person list
- Meeting notes
- List of documents collected

A template for Notes of Meetings is contained in Annex 1.

### 3.3 PROCESS REVIEW SCORING

The information obtained from the process description is used to fill in the Process Review Scoring table. Here, a score as well as motivation (reasoning) for this score is provided per criteria. The template for the Process Review Scoring Table is included in Annex 2.

The auditor needs to assess whether the systems set in place by the company provide a sufficient level of assurance that the KPI data is collected in a consistent and adequate manner. This covers the following main areas:

- (1) Organizational structure, responsibilities, and competencies;
- (2) Application of KPI Methods, and;
- (3) KPI Calculations.

For each area, a number of criteria have been developed which are critically reviewed by the auditor. A total of ten criteria exist as shown in the following Table.

**Table 1. Evaluation criteria to be applied during Process Review**

Organizational structure, responsibilities and competencies
1. <b>Position and roles:</b> Position and role of each person in the Key Performance Indicators data management process is clearly defined and implemented, from raw data generation to submission of the final data. Accountability of senior management must also be demonstrated.
2. <b>Responsibilities:</b> Specific monitoring and reporting tasks and responsibilities are included in job descriptions or special instructions for employees.
3. <b>Competencies needed:</b> Competencies needed for each aspect of the Key Performance Indicators determination process are analyzed. Personnel competencies are assessed and training program implemented as required.
Application of KPI methods
4. <b>Information Systems and process flow:</b> Adequate IT systems to collect and record data. An information/process flow diagram, describing the entire process from raw data to reported totals has been developed.
5. <b>Data transfer:</b> Where data is transferred between or within systems/spreadsheets, the method of transfer (automatic/manual) is highlighted. This is particularly relevant when reporting from departments to the Head Quarters where data is centralized and KPIs computed.
6. <b>Data trails:</b> Requirements for documented data trails are defined and implemented and all documentation are physically available.
KPI Calculations
7. <b>Use of estimates and assumptions:</b> Where estimates or assumptions are used, these are validated and periodically evaluated to ensure their ongoing appropriateness and accuracy, particularly following changes to circumstances, equipment etc. All assumptions and their motivations/reasoning are documented.
8. <b>Guidance on checks and reviews:</b> Guidance is provided on when, where and how checks and reviews are to be carried out, and what evidence needs to be documented. This includes spot checks by a second person not performing the calculations to cover manual data transfers, changes in assumptions and the overall reliability of the calculation processes.
9. <b>Internal validation:</b> Data reported from internal departments should be validated visibly (by signature or electronically) by an employee who is able to assess the accuracy and completeness of the data. Supporting information on the data limitations, problems should also be included in the data trail.
10. <b>Internal audit:</b> The company itself has performed an internal auditing process in line with the guidelines set out by ECRA in its Audit Manual.

For each criteria, a score is assigned between 1 and 3 according to the following criteria:

- Score 3: Fully compliant
- Score 2: Partially compliant
- Score 1: Not compliant at all

The results of the previous process review form the basis for the scoring. If during the previous audit a score of 3 points was assigned, the auditor should verify whether the basis for assigning this score still exists and this score can thus be maintained.

Where a score of 1 or 2 was assigned during the previous audit, the auditor should verify whether the recommended improvements from the previous audit have been implemented (or new initiatives have been introduced) and if, on that basis, the score can be increased.

Each score should be filled in and properly reasoned by the auditor in the Process Review Scoring Table. In particular where the score is less than 3 points the considerations for assigning the lower score should be explained by the auditor, also mentioning the required action items to achieve a score of 3 in the future. A sample of a process review scoring table is shown below, together with the related action items identified for the company.

**Table 2. Sample of Process Review Scoring and Action Items**

Assessment Area	Score (1-3)	Motivation/Reason	Recommended Improvements
1. Position and roles	3	Yes, : Roles & Responsibilities.pdf and MMAW-3-TD-076.doc section 4	
2. Responsibilities	3	MMAW-3-TD-076.doc section 4	
3. Competencies needed	2	Master in HV engineering, Min 10 years exp in T&D, ECRA workshop dec. 2009 (DMS)	A document should indicate the competencies needed
4. Information/process flow	3	MMAD-3-TD-017.doc	
5. Data transfer	3	Interruptions in Distribution : Recorded manually from phone calls (incident report)	

The total score from the criteria evaluation (max 30) gives an overall indication of the company's KPI management processes. However, it should be noted that this is a qualitative evaluation and the main aim is to identify and track improvement actions from each year's audits.

## 4 DATA AUDITS

### 4.1 APPROACH

Companies are required to provide ECRA with KPI data in the form of two excel spreadsheets:

- KPI Reporting Template. xls
- KPI Computation Template. xls

In addition, for the generation sector, an additional file is required (for the sites to be audited):

- Event log. xls

Data audits can only be initiated after the above KPI data templates have been received in good order from the company. In principle, the Reporting Template provides the overall company KPI values along with the calculated KPIs by region or district. The Computation Templates provide the raw data entries which are used to calculate the KPIs (formulae are embedded in the template) for the complete year and for all sites / plants in the company. By way of illustration some sample templates are shown over leaf.

Figure 1. KPI Computation Template (Distribution)

RECORDS TO BE MAINTAINED PER DEPARTMENT												
Department		Riyadh Area										
Total Delivery Points		10,000										
Record Number	Interruption ID	Start Date	Start Time	End Date	End Time	Delivery Points affected	Cause	Location	Category (Fill in "1" if applicable)			
#	#	dd-mm-yy	hh:mm	dd-mm-yy	hh:mm	#			Planned	Unplanned	Gen & Trans	
1	45482	5-Jan-2009	12:15 PM	5-Jan-2009	12:16 PM	100	Maintenance on feeder	Substation 5	1			
2	45490	6-Jan-2009	1:04 PM	6-Jan-2009	6:38 PM	200	Maintenance on feeder	Substation 6	1			
3	45522	7-Jan-2009	11:04 PM	8-Jan-2009	3:23 AM	300	Shortcircuit in breaker	Substation 8		1		
4	45529	8-Jan-2009	2:08 PM	8-Jan-2009	11:08 PM	400	Transformer short circuit	Substation 9			1	
5	45545	9-Jan-2009	9:04 PM	10-Jan-2009	2:08 PM	500	Protection system responded after generator failure	Substation 11			1	
6	45558	10-Jan-2009	3:15 PM	10-Jan-2009	3:16 PM	600	Line breakdown due to severe storm	Line 22A				
7	45596	11-Jan-2009	3:36 PM	11-Jan-2009	6:15 PM	700	Protection system responded after generator failure	Substation 11			1	
8	45626	12-Jan-2009	4:06 PM	12-Jan-2009	4:54 PM	800	Transformer short circuit	Substation 9		1		
9	45673	13-Jan-2009	4:09 PM	13-Jan-2009	6:27 PM	900	Maintenance on feeder	Substation 9	1			
10	45684	14-Jan-2009	4:54 PM	14-Jan-2009	5:20 PM	1,000	Maintenance on feeder	Substation 4	1			

Figure 2. KPI Reporting Template (Distribution)

D1. SAIFI		Total	MYAS	Riyadh City	Riyadh Region	Hail	Qassim	Dawadmi	Kharj	Makkah	Jeddah	Tabuk	Almadinah	Taif	Dammam
CATEGORY	UNIT														
Planned	Minutes/Customer														
Unplanned	Minutes/Customer														
Gen. & Trans.	Minutes/Customer														
Force Majeure	Minutes/Customer														
Total	Minutes/Customer														

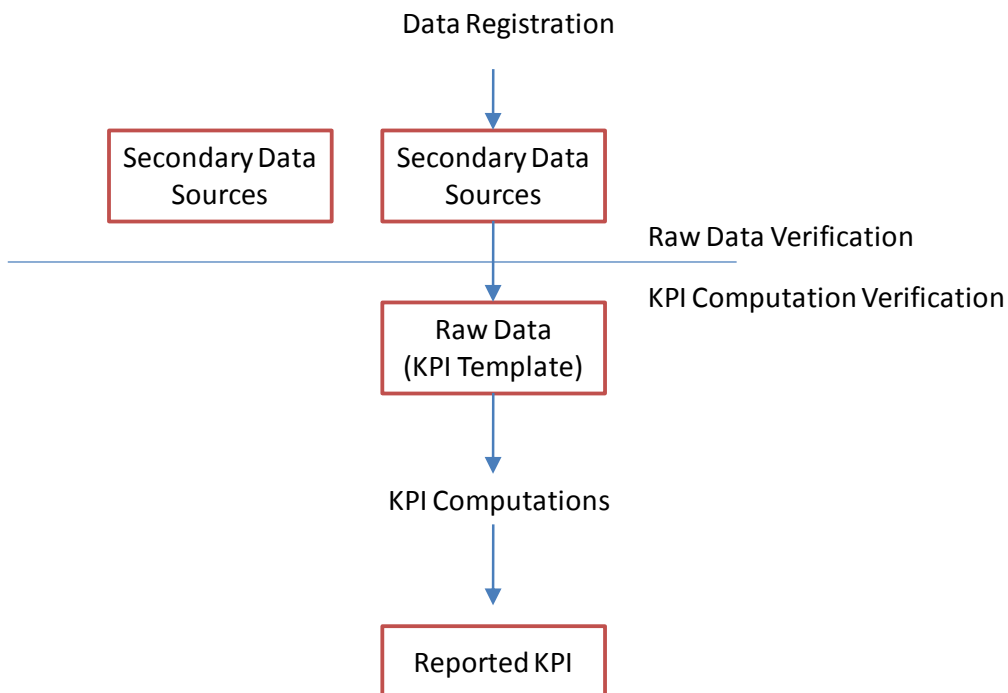
  

D2. SAIFI		Total	MYAS	Riyadh City	Riyadh Region	Hail	Qassim	Dawadmi	Kharj	Makkah	Jeddah	Tabuk	Almadinah	Taif	Dammam
CATEGORY	UNIT														
Planned	Interruption/Customer														
Unplanned	Interruption/Customer														
Gen. & Trans.	Interruption/Customer														
Force Majeure	Interruption/Customer														
Total	Interruption/Customer														

The KPI Templates have two main purposes namely (1) contain the records or "raw data" necessary to compute the KPIs, and (2) perform the KPI computations based on these

records, using standardised formulae in accordance with the KPI Manual. The data audit must therefore verify the following:

1. **KPI Computation Verification:** verification that the data provided in all KPI Templates submitted by the company is complete and the computations of the KPIs have been performed correctly. This is done before the on-site audits take place under the assumption that the raw data entries themselves are correct. However, some sanity checks can be performed, such as unusually large or small figures, comparison with previous year’s results, etc.
2. **“Raw Data” Verification:** verification that the data records entered in the templates are correct. This is done during the on-site visits by cross-checking a sample of the records in the Computation Template against the original primary and secondary data sources from the company (the distinction between these is explained in the following sections).



**Figure 3. Verification of “Raw Data” records and KPI computations**

## 4.2 KPI COMPUTATION VERIFICATION

The KPI Computation verification entails pre-checking of the KPI template files submitted by the company, before on-site visits take place. This should be carried out according to the following criteria:

- 1. Completeness:** The auditor should verify the completeness of the KPI templates (both the Reporting Template and the related Computation Template). Here, the auditor should verify that data is complete (i.e. has been filled in for all relevant plants, units, departments, operating areas, etc.) and that the correct categories have been used (e.g. planned outages vs unplanned, customer categories, etc)
- 2. Computations:** The auditor should verify that the way KPI figures have been computed is correct, assuming that the raw data entries themselves are correct. This includes the way KPIs have been aggregated such as by plant or department (to arrive at the overall company KPIs) and that formulas are used in line with the KPI Manual. Also important is to check the 'base data' and any assumptions made or average values used in the computation (e.g. total number of delivery points, average number of customers per substation affected, estimated auxiliary power consumption, etc.). The specific checks recommended for each business area are provided in Annex 4.

In principle, step 2 should be straightforward as the KPI computations are performed automatically in the KPI templates. However, to account for the possibility of accidental changes made in the file structure, manual confirmation of the KPI computations is still required. Furthermore, in some cases the data and computations may be provided in a different format than specified by ECRA. In that case, the same steps should be followed although additional checks may be required under the computation verifications.

The verification of the KPI computations can be conducted off-site. These also act as a preparation for the raw data verifications (on-site) and allow the auditor to identify any potential issues at an early stage.

## 4.3 RAW DATA VERIFICATION

In the previous step (computation verification) the assumption was made that the raw data filled in the KPI templates is correct. This assumption must be verified by checking a sample of the raw data entries from original on-site records.

The raw data verification is carried out at pre-selected company sites such as regional departments, plants, etc. The selection of these sites is notified to the company in advance and should include a range of different regions, departments, plant types, etc. The size of

sample to be reviewed, relevant to each site, is pre-determined to give the required statistical degree of confidence to the KPI results (see Annex 3).

The raw-data verification should be carried out according to the following steps (see Annex 4 for suggested auditing format to be used):

1. **Sample selection:** The auditor should select a random sample from the raw data records in the KPI Computation Template submitted by the company. For the sample size selection please refer to Annex 3.
2. **Primary and Secondary Data collection:** The auditor should identify the primary and secondary data sources and collect hard or soft copies of these data that are associated with the selected sample records. A copy of these data (soft or hard copy, photograph, etc) should be kept by the auditor.
  - Primary data: information directly relating to the selected raw data is provided by the company. This typically includes items such as operator logbooks, daily outage reports or software system, periodic summaries/reports, etc.
  - Secondary data: Sources of information that have an indirect relationship to the raw data records but can be used to cross-check whether the primary data is correct. This includes items such as network diagrams, customer databases, SCADA data, customer call records, etc.
3. **Raw Data Verification:** For the selected sample, the auditor should verify the consistency between the values shown in the KPI Computation template on the one hand, and the primary and secondary data sources on the other hand. The auditor should verify that:
  - The values contained in the primary records have been correctly entered into the KPI Computation Template.
  - There is consistency in data between the different primary sources; and
  - There is consistency between the primary and secondary data sources.
4. **Audit Sheet:** The auditor should fill in the Raw Data Audit Sheet (see Annex 5 for suggested format) in which the auditor indicates for each data record in the sample, the outcome of the audit (e.g. accept / reject data) and any observed deviations.

#### 4.4 DATA CORRECTIONS AND REVISED KPIS

Following completion of the Data Audit described above there may be deviations or errors found in either raw data entries, KPI computations or base data/assumptions. All of these need to be documented (in the formats explained above) and the final (adjusted) KPI values calculated and notified by ECRA to the company. A full explanation of data corrections and KPI adjustments must be provided in the final audit report.

## 5 AUDIT REPORT

The results of the audit should be documented in the form of an Audit Report. This report should provided a background of the company, the results of the process review, methodology of sample selection, and the results of the data audits. Based on the conclusions from the audit, the auditor should make recommendations for actions to be followed up by the company.

The Audit Report should have the following structure:

1. Introduction
  - Audit purpose and background
  - Description of the company (including number of plants, capacities, customer base, operating areas, control centres, etc) and basis of site selection
2. Audit Approach
  - Methodology followed (as described in this Audit Manual)
3. Process Review
  - Process Descriptions
  - Process Scoring (Scoring Criteria Table)
  - Actions Items (completion of previous years actions as well as new action items)
4. Data Audit
  - Sample Selection
  - Raw Data Verification
  - KPI Computation Verification
  - Data corrections and revised KPIs
5. Summary of findings
  - Overall commentary of findings
  - Final (adjusted) KPIs
  - Status of actions from previous year
  - New action items list
6. Annexes:
  - Meeting Notes
  - Contact person lists
  - List of data collected

- Extracts of data files
- Other supporting information (e.g. presentations)

## ANNEX 1: TEMPLATE FOR NOTES OF MEETINGS

### 1. General Information

Company:	
Activity (G/T/D/S):	
Date:	
Location:	
Auditors:	
KPIs Audited:	

### 2. Company Contact List

The following persons from the company were present during the meeting:

Name	Department	Position	Phone	Email

### 3. Meeting Notes

- Item 1
- Item 2
- .....

### 4. Information Collected

The following information was provided during the meeting:

Nr.	Name / Filename	Type
1	e.g. "Data.xls"	e.g. Excel file, Report, PowerPoint presentation
...		

## ANNEX 2A: PROCESS REVIEW SCORING TABLE

Assessment Area	Score (1-3)	Motivation/Reason	Action items
1. Position and roles			
2. Responsibilities			
3. Competencies needed			
4. Information Systems and Process Flow			
5. Data transfer			
6. Data trails			
7. Use of estimates and assumptions			
8. Guidance on checks and reviews			
9. Internal validation			
10. Internal audit			
<b>TOTAL SCORE</b>	....		

## ANNEX 2B: PREVIOUS YEAR ACTIONS CHECKLIST

Ref.	Action Item	Complete (Yes/No/Partly)	Comment
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	<b>TOTAL COMPLETED</b>	....	<b>% COMPLETE</b>

## ANNEX 3: RAW DATA SAMPLE SELECTION

Any selection performed of the data sample should be random.

The sample selection consists of the following steps:

1. Random selection of sites
2. Random selection of data records
3. Computation of expected error rate

### 1. Random selection of sites

The first selection entails the sites at which the data audits will take place. This selection is performed in line with the following Table.

Nr.	Audit	Nr. Sites
1	SEC - Generation	4
2	SEC - Transmission	2
3	SEC - Distribution	4
4	SEC - Customer	4
5	MARAFIQ - Generation	1
6	MARAFIQ - Transmission	1
7	MARAFIQ - Distribution	1
8	MARAFIQ - Customer	1
9	ARAMCO	2
10	SWCC	2
11	WEC	2
	<b>Total</b>	<b>22</b>

The selection of sites should be made after reviewing the total portfolio of the company and should cover a range of different regions of the country, types of plant, local vs. regional office, etc.

## 2. Random selection of raw data records

The first step of raw data selection is to review the Computation Templates submitted by the company for each business area. For each of the sites selected in step 1 a random sample should be taken.

For example, for a power plant that has 15 combined cycle power units and 5 open cycle units it would be reasonable to select 3 of the C/C units and 2 of the O/C units and from these take 2 months of data each. The raw data records (event logs) would be checked for these 2 months and the computation checked for the complete year for the selected 5 units. This would be followed by a computation check of all units to reach the overall KPIs for the plant being audited. In turn, the overall regional and company computations can be checked to ensure that the observed values of the audited plant have been aggregated correctly into the company KPI.

For the distribution business areas a 10% - 20% sample of the events in the year can be taken for the chosen location to be audited. These raw data records should be checked against the entries in the Computation Template through to the compilation at the region level and then the company level.

## 3. Computation of expected error rate

The final step is the computation of the error rate. That is the fraction of data records that contain an error. If all data records were verified then this error rate could be computed precisely. However, as verification can only be done for a part of the data records (the sample) the overall error rate has to be derived from the sample error rate. Statistically speaking the 95% confidence interval for the error rate needs to be determined. That is, the range in which we are 95% sure that the error rate will be located. This is done in the following steps.

- A random sample of data records needs to be selected. The size of the sample is given as  $n$ .
- Each of the  $n$  records is verified. The verification per record has two outcomes: "no deviation observed" or "deviation observed".
- From all  $n$  records verified, the number of records containing an error is given as  $k$ .
- The sample error rate is given by  $p = k/n$
- The confidence interval of the error rate for the population (all events) is defined as  $\pi$  and the interval  $\pi_1 < \pi < \pi_2$  is then given by the following formula:

$$\pi_{1,2} = \frac{p + \frac{z^2}{2n} \pm z \sqrt{\frac{p(1-p)}{n} + \frac{z^2}{4n^2}}}{1 + \frac{z^2}{n}}$$

For a 95% degree of confidence the value for z is equal to 1.96.

Example:

For an audit a random sample has been chosen of n=100 events. These events are checked and it turns out that after cross-checking k=2 events contain an error. The error rate for the *sample* is thus equal to  $p = 2/100 = 2\%$ . The 95% confidence interval for the error rate for *the total population* is then given by:

$$\pi_{1,2} = \frac{0.02 + \frac{1.96^2}{2 \times 100} \pm 1.96 \times \sqrt{\frac{0.02(1-0.02)}{100} + \frac{1.96^2}{4 \times 100^2}}}{1 + \frac{1.96^2}{100}}$$

From this it can be computed that  $0.006 < \pi < 0.07$ . Thus, we may conclude with 95% confidence that between 0.6% and 7% of the event records used in the computation of the KPI will contain an error.

## ANNEX 4: RAW DATA RECORDS VERIFICATION

The following provides an overview of the possible primary and secondary data sources that can be used by the auditor during the data record verification. Note that in practice the availability of data sources may vary.

GENERATION	G1. Weighted Availability Factor G2. Weighted Forced Outage Factor G3. Weighted Scheduled Outage Factor G5. Starting Reliability G7. Net Capacity Factor	
Item to check	Primary Data Source	Secondary Data Source
Gross Maximum Capacity (GMC)	Nameplate, O&M manual	
Net Maximum Capacity (NMC)	Plant commissioning info, performance test reports	
Gross actual generation (GAG)	Energy meter logs	Monthly management reports, GOIS
Net actual generation (NAG)		
Gross Annual Heat Rate (GAHR)	Fuel consumption records and Energy meter logs	Monthly management reports, GOIS
Available hours	Log books, performance data records, event records (SCADA)	maintenance planning records, monthly management reports, plant performance reports, GOIS
Service hours		
Forced Outages		
Planned Outages		
Maintenance Outages		
Actual Unit Starts		
Starting Failures		
Reserve Shutdown Hours		

DISTRIBUTION		D1 SAIDI, D2 SAIFI, D3 MAIFI	
Item to check	Primary Data Source	Secondary Data Source	
Total delivery points	Customer database	Region / district customer records	
<b>Per Outage:</b>	<b>Primary Data Source</b>	<b>Secondary Data Source</b>	
Start Date	Operator logbooks Outage/event reports	SCADA data, customer call logs	
Start Time			
End Date			
End Time			
Delivery Points affected	'Morning System' Periodic Reports (daily, weekly, etc)	Network diagrams, substation database (connectivity model, if any)	
Cause	New connections	Maintenance schedule, customer call logs	
Location	database, etc	SCADA data, Network diagrams	
Category		SCADA data, Maintenance schedules	

TRANSMISSION		T1 ENS, T2 SAIDI-T, T3 SAIFI-T, T4 MAIFI-T	
Item to check	Primary Data Source	Secondary Data Source	
Total delivery points	Asset database	Network diagrams	
Total energy supplied	Annual/monthly reports	Metering data	
<b>Per Outage:</b>	<b>Primary Data Source</b>	<b>Secondary Data Source</b>	
Start Date	Operator logbooks, Outage/event reports, 'Morning system', Periodic Reports (daily, weekly, etc)	SCADA data, metering data, network diagrams, maintenance work programme, permit book	
Start Time			
End Date			
End Time			
Power Interrupted			
Delivery Points affected			
Cause			
Location			
Voltage Level			
Category			

TRANSMISSION		Out100km	
Item to check	Primary Data Source	Secondary Data Source	
Network length	Network diagrams, Asset Database		
Per Outage:	Primary Data Source	Secondary Data Source	
Start Date	Operator logbooks, Outage/event reports, Periodic Reports (daily, weekly, etc)	SCADA data, metering data, network diagrams, maintenance work programme, permit books	
Start Time			
End Date			
End Time			
Voltage Level			
Category			

CUSTOMER SERVICE			
C2 ATSN	Primary Data Source	Secondary Data Source	
Date of Supply Request	ERP system, Customer Records	Technicians logs, call centre log	
Date of Meter Installation			
C3. ATRAP			
Date of Supply Request	ERP system, Customer Records	Technicians logs, call centre log	
Date of Meter Installation			
C5 FC, C6 FBC, C7 ATRBC			
Type of Complaint	ERP system, logging system	Correspondence (mail, fax, phone logs)	
Date Complaint Received			
Date Complaint Resolved			
C8 AWTCC			
Date	Call center logs	Call centre survey (if any)	
Reception Time of Call			
Answering Time of Call			

## ANNEX 5: RAW DATA CORRECTIONS TEMPLATE

The following format can be used as a template when reporting on the outcome of the data audit.

Record ID	No Deviation Observed	Deviation Observed			
		Item	Reason	Submitted Value	Corrected Value
1222	✓				
32323	✓				
23421		Start time	Mismatch with value in log book	10:15 am	10:20 am
4242		Delivery points	Mismatch with customer database	200	250
1321	✓				

## ANNEX 6: AUDIT CHECKLIST

<input checked="" type="checkbox"/> <input type="checkbox"/>	Item	Comment
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<b>6A</b>	<b>KPI Reporting Templates</b>	
<input type="checkbox"/>	Check for missing values (all regions, districts, plant types, etc; note come KPIs are only required after 2012)	
<input type="checkbox"/>	Check for unusual values (compare with last year)	
<input type="checkbox"/>	Check company representative name, contact details	

<b>6B</b>	<b>KPI Computation Templates</b>	
<input type="checkbox"/>	Check for missing values (all regions, districts, plant types, etc)	
<input type="checkbox"/>	Check for unusual values (compare with last year; check for high customer numbers; filter on top 10 values; use charting tool; etc)	
<input type="checkbox"/>	Carry out 'sanity checks' (e.g. KPIs by % should add to 100%; total hours sum to 8760 for the year; region/plant data sums to total company data ;)	
<input type="checkbox"/>	Check formulae are correct (e.g. paste values into ECRA original worksheet)	
<input type="checkbox"/>	Check classification of incidents, event types (planned, unplanned, force majeure, etc)	
<input type="checkbox"/>	Check base data (number of delivery points, total number of customers, etc)	

6C	Site visit checklist	
<input type="checkbox"/>	Check selected sample from computation template against original source documents (primary data records)	
<input type="checkbox"/>	Check sample data against secondary records	
<input type="checkbox"/>	Compile data corrections / KPI adjustments table	
<input type="checkbox"/>	Check local documents showing KPI calculations and submission to regional level / head office	
<input type="checkbox"/>	Obtain copies of original raw data records and other supporting documents	
<input type="checkbox"/>	Record company representative details and contact information	